TOLYPELLA CANADENSIS, A CHAROPHYTE NEW TO THE EUROPEAN FLORA

Anders LANGANGEN

Hallagerbakken 82 B, 1256 Oslo, Norway

ABSTRACT - *Tolypella canadensis* Sawa, formerly endemic to Canada is now found in Scandinavia, in Lake Glomdalsvatn in North-Norway and in Karesuando in North-Sweden. Specimens from the two localities are described and two new forms are described, forma *glomdalensis* and forma *hasslowii*. *Tolypella canadensis* is ■ species prefering oligotrophic lakes, with some steamy and cold water. It is found only on laomy bottom, on medium depths. In 1992 ripe oospores were only found in Karesuando. In Lake Glomdalsvatn the species was richly fructifying, but no ripe oospores were found.This must probably vary from year to year. The species is perennial, and due to the unfavourable conditions vegetative reproduction is important. The amphiatlantic distribution of *Tolypella canadensis* is mentioned, but I have not tried to explain it fully as I believe that the species is more widely distributed than the finds show.

RÉSUMÉ - *Tolypella canadensis*, auparavant connu seulement au Canada, a été observé en Scandinavie dans le lac Glomdalsvatn au Nord de la Norvège et ■ Karesuando au Nord de la Suède. Deux nouvelles formes sont décrites: forma *glomdalensis* et forma *hasslowii*. Il semble que *Tolypella canadensis* préfère les lacs froids et pauvres en substances nutritives. Cette espèce a été trouvée seulement ■■ fond sablonneux de profondeur moyenne (environ 2-3 mètres); en 1992, des oospores mûres ont été trouvées seulement a Karesuando; dans le lac Glomdalsvatn l'espèce donne de nombreuses fructifications, mais aucune oospore mûre n'a été observée. Cette espèce est pérennante et, du fait de conditions de croissance difficiles, la propagation végétative est importante. La distribution amphiatlantique de *Tolypella canadensis* est mentionnée, mais cette répartition étant vraisemblablement plus vaste, elle n'a pas été discutée.

KEY WORDS : Charophyta, *Tolypella canadensis*, new forms, distribution, Canada, Norway, Sweden.

INTRODUCTION

The Glomdalen area in Northern Norway is famous because of its karst phenomena (Lauritzen, 1983). The area is now a part of Saltfjellet National Park.

In connection with an excursion to the area in 1986 I found rich, luxuriant stands of *Nitella flexilis* in many small waters in the northern part of the valley (Langangen, 1986). At that time I did not collect any specimens of charophytes from Lake Glomdalsvatn.

In 1991 I arranged a field trip to Saltfjellet with a group of my students. On this trip we found ■ charophyte growing in small tufts on the bottom of the lake's out-

let. On determining these specimens later, they turned out to be a new species to Europe, *Tolypella canadensis* Sawa. The species was described in 1973 by dr. Sawa in Canada and named in honour of this country (Sawa 1973).

On this first excursion to Lake Glomdalsvatn I collected a few specimens only. In 1992 I visited the locality again and made an appointment with a local inhabitant, Ole Fiskkjønn, to collect specimens for me regulary through the rest of the year, in order to follow the biological development of the species.

In working with some herbarium specimens of *Nitella mucronata* (A. Br.) Miquel I came accross another find of *Tolypella canadensis*, collected in Karesuando, North Sweden in 1909. Through a local person, Åke Siikavupio, I managed to get living specimens of the species from the same area. Living specimens have been collected at the following dates and localities :

Date	Locality	Collector
17.07.1992	Lake Glomdalsvatn	Anders Langangen
16.08.1992	Lake Glomdalsvatn	Ole Fiskkjønn
07.09.1992	Karesuando (Sweden)	Åke Siikavupio
20.09.1992	Lake Glomdalsvatn	Ole Fiskkjønn
25.10.1992	Lake Glomdalsvatn	Ole Fiskkjønn
31.03.1993	Lake Glomdalsvatn	Ole Fiskkjønn
18.05.1993	Lake Glomdalsvatn	Ole Fiskkjønn

Material examined in this paper is deposited in the Phycological Herbarium of Botanical Museum, University of Oslo.

DESCRIPTION OF THE MATERIAL EXAMINED

The Glomdalen material

Plants monoecious. Green, *Nitella*-like, unincrusted, perennial. In contrast to *Nitella* this species often has a stiff look. Height 4-20 cm, depending on place of growth. Axial diameter 375-400 µm. (Fig. 1-2).

Sterile specimens common. They have 5-6 simple branchlets in each whorl. Length of branchlet to 8mm, each consisting of 2-3 relatively long cells, diameter 250-350 µm and one mucro. Mucro, 1-2 celled, 75-200 µm long and 50-100 µm wide at base. Upper whorls with branchlets longer (to 2x) or equal in length with the internodes. At lower whorls the branchlets are commonly only 1/3 of the length of internodes. Internodes to 4 cm.

Fertile specimens not uncommon, with both sterile and fertile whorls, 6-7 branchlets per whorl. Gametangia most common in dense heads, but also directly from the stemnode and 1. and 2. node of branchlets. Fertile branchlets often with 1-2 single, 2-4 celled secondary rays (Fig. 2) at 1. node. Branchlets with 3-4 cells and a short mucro as in sterile branchlets. Sterile branchlets in fertile whorls single. Branchlets on fertile whorls slightly bend inwards to the stem, this often gives the alga a peculiar appearance. Oogonia 1-4 aggregated, light brown, at fertile branchlets. Length 675-500 µm including coronula, and 400-500 µm wide, with 8-9 convolutions. Coronula 30-50 µm high, 30-60 µm wide at base. Oogonia stalked, stalks 250-350 µm long, 90-120 µm wide. Dwarf oogonia without content is common. Oospore (unripe) brown, 250-325 µm long, 275-300 µm wide. Basal impression simple. Antheridia single or in

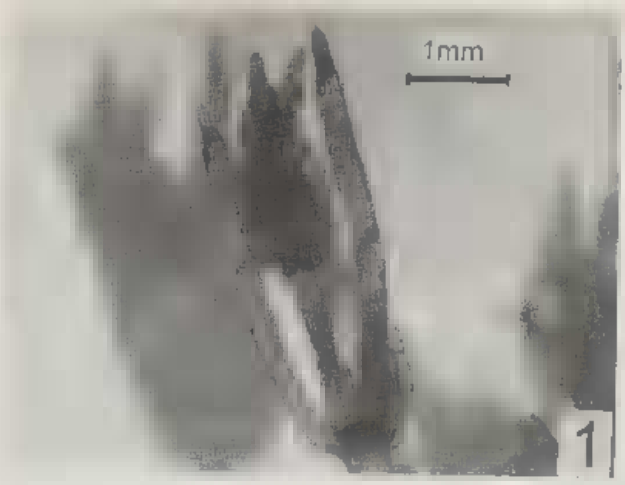


Figure 1. *Tolypella canadensis:* Top of a fertile specimen from Lake Glomdalsvatn 28.8.1991. From the middle node one can see a stalked antheridium.

Figure 2. *Tolypella canadensis:* Fertile branchlet with two secondary rays. Lake Glomdalsvatn 20.9.1992.

Figure 3. *Tolypella canadensis:* Antheridium and oogonium with stalkcells. Lake Glomdalsvatn 20.9.1992.

pair, alone or mixed with oogonia. Protandrous. Antheridia 325-375 µm in diameter, stalked. Stalk cells 300-350 µm long (Fig. 3).

Lower parts of of the plants have enlarged starchbearing cells. Such "bulbils" were specially big in specimens from March 1993 and they gave the plants a peculiar look. They were up to 2 mm in diameter, and from each bulbil arise numerous unicellular rhizoids.

The Karesuando material.

Plants monoecious. Height 10-27 cm. Most specimens were sterile, only a few were fertile. Most branchlets simple, but on fertile branchlets short, secondary rays were common. Branchlets with 3-4 cells, including mucro. The mucro consists of two short cells (Fig. 4).

Gametangia most common on stemnodia or 1. node of branchlets. Only one specimen had gametangia in heads. Oogonia 600-700 µm long (included coronula), 425-500 µm wide, convolutions 8. Oogonia stalked, stalk 100 µm long. Oospore (1 ripe) brown, 400 µm long, 320 µm wide, with 6 prominent ridges, 40 µm high. Antheridia not found in 1992. The 1909 material is different, as it consists of smaller plants, rich fructifying (Fig. 5).

CYTOLOGY

A chromosomal count was done on material from Glomdalsvatn collected 16.8.1992. I used live specimens, where I dissected out young antheridia. These were stained in aceto-orcein and then squashed. In some antheridial filaments it was now possible to count the chromosome numbers of the metaphase stage of mitosis.

The chromosome number was n = 8 (Fig. 7), which is in accordance with Sawa (1973).

ECOLOGICAL OBSERVATIONS

In Scandinavia *Tolypella canadensis* is found in oligotrophic waters. Lake Glomdalsvatn is a typical oligotrophic lake, where the algae are found in the lake itself and most common in and around its outlet. This is presumably because the current is stronger here. Lake Aidnuvaipiijøvri in Karesuando is ■ oligotrophic "Lagune-see" with presumed fast running water as the river Könkämäälven runs through the lake. In lake Glomdalsvatn and certainly also in Karesuando the waterlevel in the lakes are varying much during the seasons. This must be the reason why so many plants in July and August 1992 in Lake Glomdalsvatn were physically damaged.

The algae seem to prefer fine sandy sediments. In Lake Glomdalsvatn the bottom is fine sand with a certain content of clay, or loam. In Karesuando the bottom is sand. At the mouth of Lake Glomdalsvatn *Tolypella canadensis* were growing in small, tufted groups, at a depth of 0.5-2m. Such groups were often growing close together, thus creating in parts of the outlet dense carpets of this species only. The height of specimens in such colonies is commonly 5-10 cm. Some mosses were mixed with the algal colonies. In the area between the outlet and the lake where the current can still be strong the algae were pressed down against the bottom. In the lake *T. canadensis* were growing in mixed populations with *Nitella flexilis* and some phanerogames. The specimens here were measured to 20 cm, but are presumably longer. In the lake the two charophytes have very similar growth forms, high, thin and with short whorls and long internodes. This is also the case with *Nitella opaca* in Karesuando.

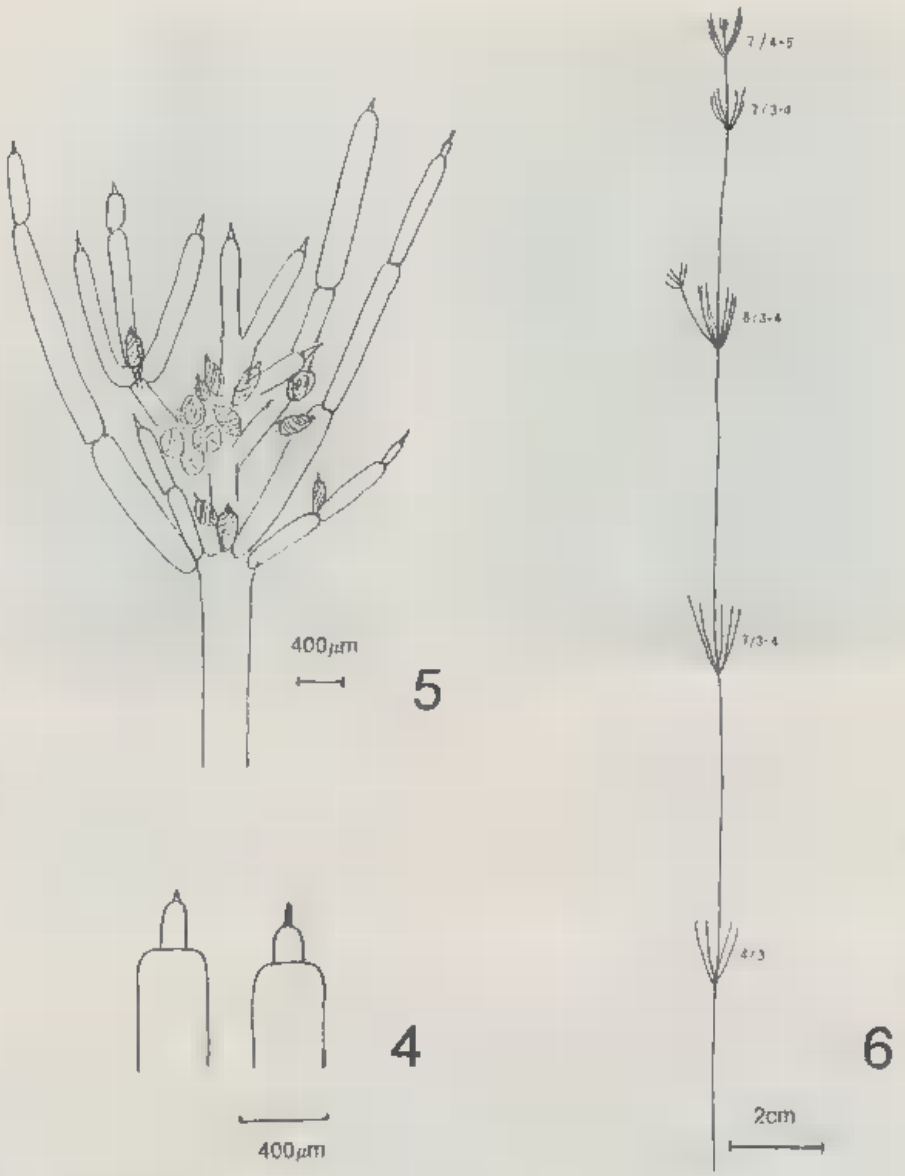


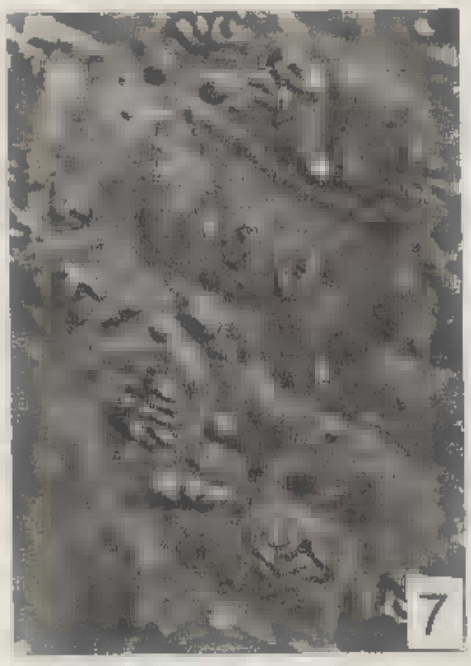
Figure 4. *Tolypella canadensis:* Apices of branchlets. Karesuando 7.9.1992.

Figure 5. *Tolypella canadensis:* a) Drawing of specimen from Karesuando 1909. The specimen was rich fructifying, with both oogonia and antheridia. In each whorl 8 branchlets. Fertile branchlets with secondary rays. No mature oospores.

Figure 6. *Tolypella canadensis* forma *glomdalensis* n.f., drawing of specimen from Karesuando 7.9.1992. First number to the right is branchlets in each whorl, second number is cells (inc. mucro) in each branchlet.

These growths form are here presumed to be ecotypes, adapted to these extreme habitats with cold, fluctuating and flowing water.

In Lake Glomdalsvatn I found *Ranunculus peltatus* Schrank (sterile) and the submerse moss, *Dicranella palustris* (Dicks.) Crundw. growing together with *Tolypel-*



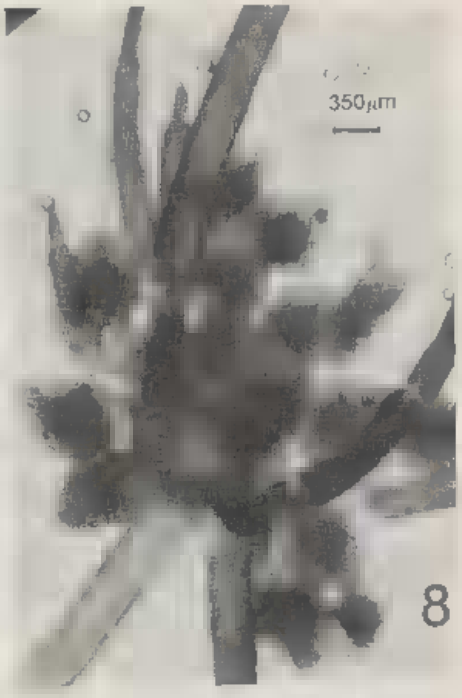


Figure 7. *Tolypella canadensis:* 8 metaphase chromosomes from antheridial filaments. Lake Glomdalsvatn 16.8.1992.

Figure 8. *Tolypella canadensis:* forma *hasslowii* n.f., photo of specimen from Lake Glomdalsvatn 25.10.1992. Branchlets with mucro. Oogonium with stalk cell can be seen.

la. In the material from Karesuando I found *Ranunculus peltatus, Potamogeton bechtoldii* Fieber and water-mosses. These are typical oligotrophic species.

The chemical values I have measured are shown in Table I.

Loc.	Date	pH	µScm^{-1}	Ca mg l^{-1}	Cl mg l^{-1}	Temperature (°C)
Glomdalsvatn	17.07.92	7,0	32,4	6,0	-	-
"	16.08.92	7,0	36,2	4,0	<2,5	11,0
Karesuando	13.10.92	6,6	36,9	4,0	1,0	-
Glomdalsvatn	20.9.92	7,0	34,6	4,0	1,2	10,0
"	25.10.92	7,0	60,9	4,0	2,5-5,0	4,5 Ice
"	31.03.93	7,0	105,1	1,4	2,5	3,0 Ice
"	18.05.93	6,8	89,0	6,0	15,0	4,0 Flood

Table I. Some chemical and physical parameters from the localities examined.

The relatively high values of pH in Lake Glomdalsvatn can be due to a supply of lime from the karstarea. The other parametres shows clearly that the localities are oligotrophic.

Temperature

In Scandinavia *Tolypella canadensis* seems to prefer relatively cold water (Tab. I). The temperatures measured in Lake Glomdalsvatn are from the surface.

Attempt to cultivate the species of material collected on both 16.8. and 20.9.92 failed. The algae were put in glassjars outdoors, but they died after a few days. This was probably due to the high temperatures at that time.

In October the air temperature was lower, and specimens from this collection were still growing two months later. The specimens were green and healthy. In December 1992 the air temperature dropped well below zero, and the water with the algae froze to ice. After melting, the algae were still ■ healthy as before, both sterile and fertile plants. Plants collected in March 1993 were still growing well two months later, and they developed small antheridia and some small oogonia.

Epiphytes

Both in Lake Glomdalsvatn and in Karesuando *Bulbochaete* sp. was a common epiphyte on *Tolypella canadensis*. In Lake Glomdalsvatn the diatom *Fragilaria* sp. was frequently found on the alga. Even more common in this lake is *Coleochaete nitellarum* Jost which lives both endo- and epiphytic in the membrane of charophytes without cortex. In this locality some algae were so infested that *Coleochaete* must have caused harm.

In dead specimens after the cultivation attempt with specimens from 20.9.92, *Coleochaete* developed masses of ripe oospores after three weeks. The decomposing *Tolypella* specimens were also overgrown by Phycomycetes. *Coleochaete* was also found in March 1993.

Coleochaete nitellarum was also found on *Nitella flexilis*, but this species was not so heavily infested.

SOME BIOLOGICAL OBSERVATIONS

In all collections there were both sterile and fertile specimens. The small tufted plants were very often luxurantly fructifying. Antheridia and oogonia are found from July to October. Even in March 1993 I found some brown, not ripe oogonia. Antheridia is most common in young plants or shoots, which indicate protandrous development. On older plants and shoots oogonia are often dominant.

In the examined material only one ripe oospore was found on ■ specimen from Karesuando, collected 7.9.92. In specimens from Lake Glomdalsvatn, from 20.9.92 and especially from 25.10.92 brown oogonia with unripe oospores were common (Fig. 8). Such oogonia were also found in March 1993. It is reasonable to believe that the conditions in Lake Glomdalsvatn are not always favourable for a full development of the oospores of *Tolypella canadensis*.

In comparison, *Nitella flexilis* was found with ripe, black oospores on 20.9.92.

DESCRIPTION OF TWO NEW FORMS OF *TOLYPELLA CANADENSIS*

Tolypella canadensis has been described in detail by Sawa (1973). The species belongs to the Section Acutifolia T.F.A. (Rothia R.D.W.) where the endcells of the rays are forming a mucro.

When Hasslow (1939) determined a charophyte collected in Karasuando in 1909 to be *Nitella mucronata*, he must have used the mucro as an important detail. But he also realised that the specimens he examined were different from *Nitella mucronata*. In his note from 1939 he states "Von zwei Aussnahmen an den unteren Kränzen abgesehen, waren alle Kranzzweige ("Blätter") ungeteilt, indem sich an den Teilungspunkten keine Seitensegmente ausgebildet hatten. Während die unteren Kranzzweige oft nur zweizellig waren, wobei die äusserste Zelle einen sehr kleinen und dünnen Mukron bildete, bestanden diejenigen der oberen Kränze ▬ 4 (oder ausssnahmensweise 5) Zellen, den kurzen Mukron mitgerechnet, und sie zeigten folglich einen mehrzelligen Hauptstrahl, wie oben gesagt ohne alle Teilungen. Die fertile Kranzzweige waren Köpfchenbildend mit den Fruktifikationsorganen sehr gedrägt. Das gesammelte Material war gering, einige Stückchen von höchstens 10 cm Länge." This description of *Tolypella canadensis* which Hasslow gives here will be used here to describe a form of the species. Concerning the level of the taxon, Hasslow describes it ▬ *Nitella mucronata* A.Br. f. *haplophylla* Hasslow (Fig. 5). He had in mind to describe it as a variety, but as the careful man he was he writes "Wenn man darüber Gewissheit hätte, ob der Bestand der Pflanze durchgehend gleich wäre und sich von Jahr zu Jahr gleich hielte, so hätte man wohl den Fund als Var. aufnehmen können, aber nun muss man bis auf weiters sich damit zufrieden geben, ihn als Form zu bezeichnen, eine Form, die vielleicht nur zufällig ist."

The material examined by me can be divided in two types. These two types are here described as two forms of *Tolypella canadensis*.

***Tolypella canadensis* Sawa f. *glomdalensis* n.f.** (Fig. 6)

Nitella-like. To 27 cm high. Internodes to 6.5 cm. Whorls short, to 1.5 cm. 4-8 branchlets in a whorl. Each branchlet with 3 - cells and one mucro. Most sterile specimens. In fertile specimens the gametangia are found growing from stemnodia or on 1. node of branchlets.

This form is found both in Karesuando and in Lake Glomdalsvatn. It is presumably an ecotype, adapted to deeper water in more or less stagnant water in lakes.

Nitellae-similis. Altae ad 27 cm . Internodiis ad 6.5 cm. Verticillum breve ad 1.5 cm. 4-8 ramuli, in verticillo, 3-4 cellulares, cellula ultima mucronem formans. Specima plurima sterila. Gametangia ad nodos ramulorum fertilium.

***Tolypella canadensis* Sawa f. *hasslowii* n.f.** (Fig. 8)

Growing in tufted colonies. Height to 10 cm. Whorls to 0.7 cm, often longer than internodes. Commonly rich fructifying, with gametangia in heads.

This form is found both in Karasuando and in Lake Glomdalsvatn. The form fits the description of the species given by Sawa (1973) and Hasslows form from 1939. It is presumably an ecotype, adapted to shallow to medium deep, often strongly streaming waters.

Plantae ad 10 cm altae. Verticillum ad 0.7 cm, saepe longius quam internodii. Gametangia capitula formantes.

DISTRIBUTION OF *TOLYPELLA CANADENSIS*

Tolypella canadensis has been found in Canada and in Scandinavia (Fig. 9 and 10). The localities are listed below:

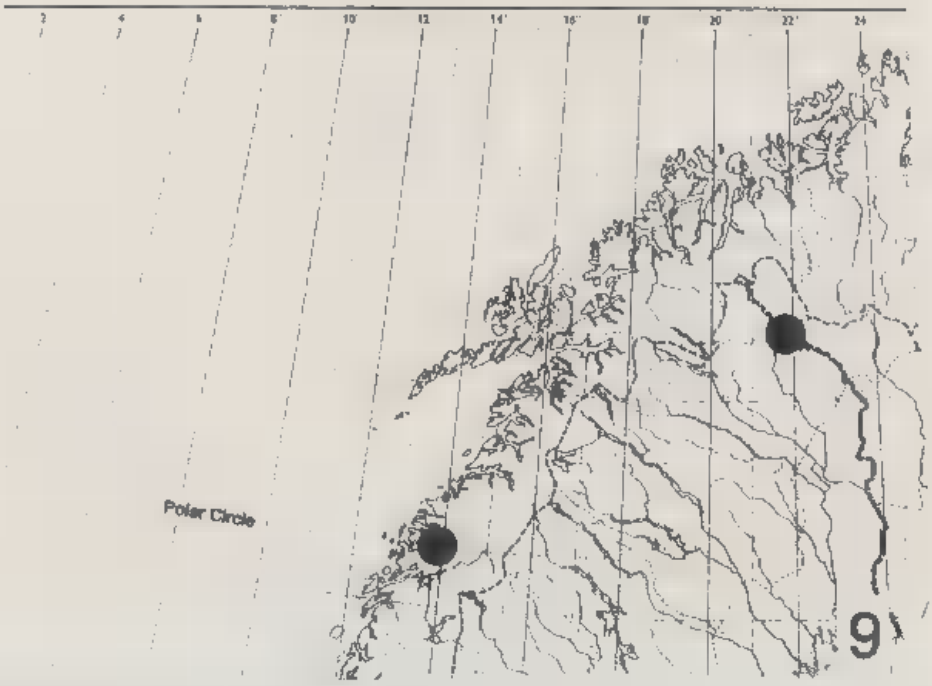


Figure 9. *Tolypella canadensis:* Distribution in Scandinavia.

Sweden

1. Torne Lappmark. Karesuando. Lake Ainettivarpanjävri (West of the mountain cabin Naimakka). July 1909. Leg. Thore C.E. Fries (Herb. Uppsala) (see Hasslow, 1939 p. 295).

2. Torne Lappmark. Karesuando. Lake Aidnuvarpijövri. The river Könkämäälven runs through the lake. 7.9.1992. Leg. Åke Siikavupio (Herb. Oslo, Herb. Uppsala).

Norway

1. Nordland. Rana. Lake Glomdalsvatn.

a) 28.08.1991 leg. Anders Langangen, b) 17.07.1992 leg. Anders Langangen, c) 16.08.1992 leg. Ole Fiskkjønn, d) 20.09.1992 leg. Ole Fiskkjønn, e) 25.10.1992 leg. Ole Fiskkjønn, f) 31.03.1993 leg. Ole Fiskkjønn, g) 18.05.1993 leg. Ole Fiskkjønn (all in Herb. Oslo)

Canada

1. Ontario. Thunder Bay. The shore of Lake Superior 0.2 mile east of Rossport. 20.7.1970 (Holotype) (Sawa 1973).

2. Ontario. Lake Huron in the inlet to Georgian Bay. 1981 (Sawa pers. comm.).

Figure 10. *Tolypella canadensis:* Known distribution.

DISCUSSION

Tolypella canadensis endemic to Canada has now been found in Scandinavia. The two scandinavian localities are in the northern part of this area, at the Polar circle and north of this. The Scandinavian specimens differ in many respects from the Canadian counterparts. There are both morphologically and ecological differences, our specimens show a bigger variation and their places of growth are different. In Lake Superior the algae grow on soft humus bottom, while here it is found on loamy sediments. In Canada the species has been found down to ▮ meters deep in Lake Huron (Sawa pers. comm.), while here it is found on shallower places.

Tolypella canadensis seems to prefer cold waters. In Lake Glomdalsvatn the temperature on the surface has been measured from 11-3.0°C, and even lower in my glassjars. In Canada Sawa (1973) also gives relatively low temperatures, 12-17°C. Green shoots have been found from July to May, which proves that the species is perennial.

The winter must be a kind of bottleneck for *Tolypella canadensis* in Scandinavia. Lake Glomdalsvatn was on 25.10.1992 covered by ice, 6-7 cm thick. This, combined with much snow, which is common it the area, and the dark period by and north of the Polar Circle must reduce the penetration of light in the water radically. This means that the metabolic processes of *Tolypella canadensis* must be very low during wintertime. The conditions around the outlet are perhaps different, as the ice here often breaks because of the current of the water. This should be more closely examined.

The observed morphological similarities between *Tolypella canadensis* and *Nitella flexilis* show a similar adaption to this extreme environment. It seems that ecorticate charophytes are better adapted to cold water than corticated are. This also seems to be true as ecorticated forms of *Chara* have been collected in cold springs at Svalbard, and corticated forms have been collected in nearby warm springs (Langangen in prep.).

Cytologically *Tolypella canadensis* (and *T. boldii* Sawa) differ from the other members of the genus *Tolypella* by having chromosome number n=8. Sawa (1973)

have a detailed discussion of this phenomenon, and he concludes that the chromosome-number supports the idea that the two mentioned species represent a new taxonomic group within the section *Acutifolia*. I agree with this conclusion, and I would like to suggest naming this group after Hasslow.

Tolypella canadensis has a amphiatlantic distribution. This kind of distribution is well known among phanerogames, and is much discussed (Dahl, 1991).

As *Tolypella* is a very old genus dating back to oligocene (Grambast, 1974) or even beyond this (jura) (Horn af Rantzien, 1954), it is possible that *Tolypella canadensis* has survived from before the separation of the land masses, as many freshwater red algae are supposed to have done (Sheath & Hambrook, 1990). A problem with this model is how to explain how the alga could survive the glaciations in late Weichselian and earlier. In late Weichsel ice covered the areas where *Tolypella canadensis* now lives (Denton & Hughes, 1981).

Wading waterfowls are important dispersal vectors for charophytes (Proctor, 1962), and this is may be the easiest way to explain the recent distribution of *Tolypella canadensis*. There is reason to believe that the alga is more widely distributed that our present knowledge shows. The alga should be looked for in northern parts of Russia, Alaska and northern parts of Canada.

Acknowledgements - I am in debt to Ole Fiskkjønn and Åke Siikavupio who collected living algae for me. I am also grateful to thanks to Forsker Erik Syvertsen, Institute of marine biology, University of Oslo who helped me with the microphotography of the chromosomes, and to three of my collegues at Oslo Cathedral School, Oslo, Lektor Betsy Hansen who have read my manuscript and corrected my English language, Lektor Hilde Sejersted who has translated the latin diagnosis and Lektor Toril Sørensen who has translated the French résumé. Thank you also to Rune Økland, Botanical Museum, Oslo for determination of the moss.

LITERATURE

DAHL E., 1991 - Nunatakkteorien III - amfiatlanter og disjunkter. *Blyttia* 49: 17-33.

DENTON G.H. & HUGHES T.J.(red.), 1981 - *The Last Great Ice Sheet*. Wiley & Sons.

GRAMBLAST L.J., 1974 - Phylogeny of the Charophyta. *Taxon* 23: 473-481.

HASSLOW O.J., 1939 - Einige Characeenbestimmungen. *Bot. Notiser* 1939: 295-301.

HORN AF RANTZIEN H., 1954 - Middle Triassic Charophyta of South Sweden. *Opera Botanica* 1, 2: 1-83.

LANGANGEN A., 1986 - Kransalgen *Nitella flexilis* funnet på Saltfjellet. *Blyttia* 45: 11.

LAURITZEN S.E., 1983 - *Arctic and Alpine Karst Symposium, August 1-15, 1983. Program and Field Guide*. Dept. of Chemistry, University of Oslo.

PROCTOR V.W., 1962 - Variability of *Chara* oospores taken from migratory water birds. *Ecology* 43: 528-529.

SAWA T. 1973 - Two new species of *Tolypella* (Characeae) from North America. *J. Phycol.* 9: 472-482.

SHEATH R.G. & HAMBROOK J.E., 1990 - Freshwater ecology *in* Cole M. & G. Sheath; *Biology of The Red Algae*. Cambridge University Press, pp. 423-453.